Method of Test for

AIR CONTENT OF FRESHLY MIXED CONCRETE

DOTD Designation: TR 202-83

METHOD A - VOLUMETRIC METHOD

Scope

1. This method of test covers the procedure for determining the air content of freshly mixed concrete with a slump of 1 in. (25 mm) or greater by determining the volumetric displacement of air with water after thorough agitation.

Apparatus

2. (a) *Air Meter* - An air meter (Figure 1) consisting of a bowl and a top section conforming to the following requirements:

(1) *Bowl* - The bowl shall be constructed of machined metal of such thickness as to be sufficiently rigid to withstand normal field use and of such composition as not to be readily attacked by cement paste. The bowl shall have a diameter equal to 1 to 1.25 times the height and be constructed with a flange at or near the top surface. Bowls shall not have a capacity of less than 0.075 ft^3 (0.002 m^3).

(2) *Top Section* - The top section shall be

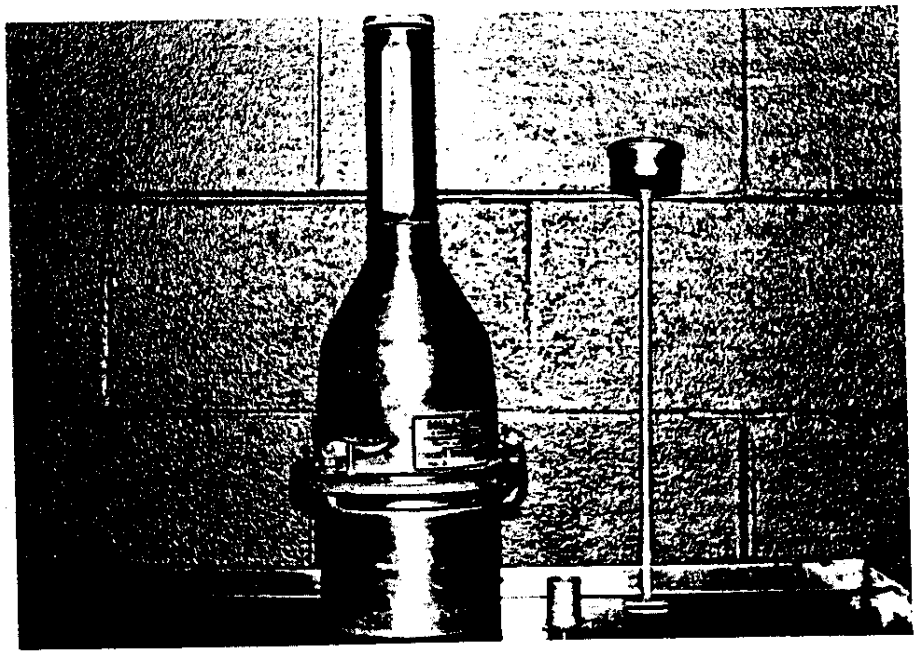

Figure 1

constructed of machined metal of thickness sufficiently rigid to withstand normal field use and of composition not readily attacked by cement paste. The top section shall have a capacity at least 20% larger than the bowl and shall be equipped with a flexible gasket and with hooks or lugs to attach to the flange on the bowl to make a watertight connection. The top section shall be equipped with a glass-lined or transparent plastic neck, graduated in increments not greater than 0.5% from 0 at the top to 9%, or more, of the volume of the bowl. The upper end of the neck shall be threaded and equipped with a screw cap having a gasket to make a watertight fit.

(b) *Funnel* - A metal funnel with a spout of a size permitting it to be inserted through the neck of the top section and long enough to extend to a point just above the bottom of the top section. The discharge end of the spout shall be so constructed that when water is added to the container there will be a minimum disturbance of the concrete.

(c) *Tamping Rod* - A round, straight steel rod, 5/8 in. (16 mm) in diameter and approximately 24 in. (610 mm) in length, having one end rounded to a hemispherical tip the diameter of which is 5/8 in.

(d) *Strike-off Bar* - A steel bar approximately 1/4 x 1 x 12 in. (6 x 25 x 305 mm) long.

(e) *Measuring Cup* - A metal cup having a capacity equal to 1.0% of the volume of the bowl of the air meter.

(f) *Syringe* - A small rubber bulb syringe having a capacity of at least that of the measuring cup.

(g) *Pouring Vessel* - A metal or glass container of approximately 1 qt. (1 litre) capacity.

(h) *Trowel* - A blunt-nosed brick masons' trowel.

(i) *Scoop* - A small metal scoop.

(j) *Isopropyl Alcohol* - Use 70% by volume isopropyl alcohol (approximately 65% by weight).

NOTE: Seventy percent isopropyl alcohol is commonly available as rubbing alcohol. More concentrated grades can be diluted with water to the required concentration. Other alcohols or defoaming agents may be used if calculations show that their use will result in an error in indicated air content less than 0.1%.

(k) *Glass Plate* - A glass plate at least 1/2 in. (13 mm) thick with a length and width at least 2 in. (51 mm) greater than the diameter of the bowl.

Calibration of Apparatus

3. (a) The volume of the bowl of the air meter, in cubic feet or cubic meters, shall be determined by accurately weighing the amount of water at 70F (21.1C) required to fill it, and dividing this weight by the unit weight of water at 70 F, namely 62.3 lb/cu. ft. (997.97 kg/m^3). A glass plate shall be used to cover the bowl to remove excess water and to ensure that the container is full.

(b) The accuracy of the graduation on the neck of the top section of the air meter shall be determined by filling the assembled measuring bowl and top section with water to the level of the mark for any air content. A quantity of water at 70F (21.1C) equal to 1.0% of the volume of the bowl, shall be added to the water already in the neck. The height of the water column shall increase by an amount equivalent to 1.0% of air.

(c) The volume of the measuring cup shall be checked by adding one cupful of water to the assembled apparatus in the manner described in paragraph 3(b). Such addition shall increase the height of the water column by an amount equivalent to 1.0% of indicated air.

Sample

4. A representative sample of concrete to be tested shall be obtained in accordance with DOTD Designation: S 301 of the Materials Sampling Manual.

Procedure

5. (a) *Consolidation* - Using the scoop, aided by the trowel if necessary, fill the bowl with freshly mixed concrete in 1 layer and rod 25 times with the tamping rod. Tap the sides of the bowl 10 to 15 times after rodding as outlined in Section 5 of DOTD Designation: TR 201, Method of Test for Weight per Cubic Foot, Yield, and Air Content.

(b) *Striking Off* - After placement of the concrete in accordance with paragraph 5(a), strike off the excess concrete with the strike-off bar until the surface is flush with the top of the bowl. Wipe the flange of the bowl clean.

(c) *Adding Water* - Clamp the top section into position on the bowl, insert the funnel, and add water until it appears in the neck. Remove the funnel and adjust the water level, using the rubber syringe, until the bottom of the meniscus is level with zero mark. Attach and tighten the screw cap.

(d) *Agitating and Rolling* - Invert and agitate the unit until the concrete settles free from the base; then, with the neck elevated, roll and rock the unit until the air appears to have been removed from the concrete. Set the

apparatus upright, jar it lightly, and allow it to stand until the air rises to the top. Repeat the operation until no further drop in the water column is observed.

(e) *Dispelling Bubbles* - When all the air has been removed from the concrete and allowed to rise to the top of the apparatus, remove the screw cap. Using the syringe, add in one-cup increments (using the measuring cup specified in paragraph 2(e)) sufficient isopropyl alcohol to dispel the foamy mass on the surface of the water.

(f) *Reading* - Make a direct reading of the liquid in the neck, reading to the bottom of the meniscus to the nearest graduation on the air meter (0.5%).

Calculation

6. Calculate the air content of the concrete to the nearest 0.5 percent by adding the number of cups of alcohol added in accordance with paragraph 5(e) to the reading obtained in paragraph 5(f).

Report

7. Report the air content to the nearest 0.5 percent.

Reference

AASHTO Designation: T 196

Normal testing time is 15 minutes.

DOTD Designation: TR 202-83

METHOD B - PRESSURE METHOD

Scope

1. This method of test covers the determination of the air content of freshly mixed concrete with a slump of less than 1 in. (25 mm) from observations of the change in volume of concrete with a change in pressure. A detailed procedure employing one type of apparatus is described. Apparatus of other designs have been developed and appropriate procedures have been prepared for use with such apparatus.

This method is not applicable for concretes made with highly porous aggregates.

Apparatus

2. (a) *Air Meter* - An air meter (Figure 1) consisting of a measuring bowl and cover assembly conforming to the requirements shown below. The operating principle of this meter consists of equalizing a known volume of air at a known pressure in a sealed air chamber with the unknown volume of air in the concrete sample. The dial on the pressure gage shall be calibrated in terms of percent air for the observed pressure at which equalization takes place.

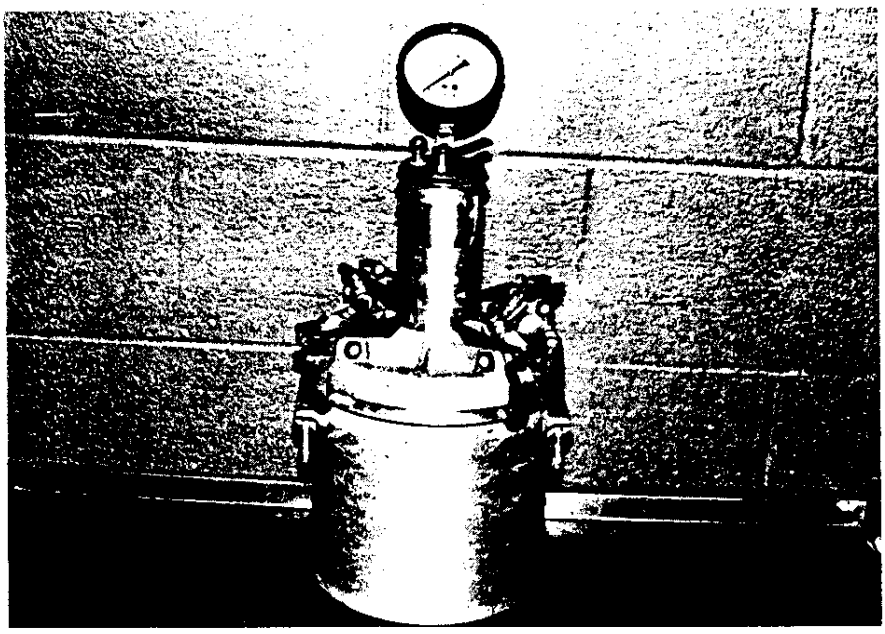

Figure 1

(1) *Measuring Bowl* - The measuring bowl shall be a flanged cylindrical bowl, made of hard metal not readily attacked by the cement paste, having a diameter equal to 0.75 to 1.25 times the height and a capacity of at least 0.20 $ft.^3$ (0.006 m^3).

(2) *Cover Assembly* - The cover shall be made of hard metal not readily attacked by the cement paste. It shall have smoothly machined interior surfaces contoured to provide an air space above the level of the top of the measuring bowl. It shall be flanged or otherwise constructed such that the cover and the measuring bowl can be fitted together into a pressure-tight assembly. The cover shall be fitted with a gage for obtaining a direct reading of air content. The graduations for a suitable range in air content shall be in percent and tenths of a percent as determined by the proper air pressure calibration test.

The cover shall be fitted with an air bleeder valve for venting of the air chamber, a main air valve, and petcocks for bleeding off water as required. Suitable means for clamping the cover to the bowl shall be provided to make a pressure-tight seal without entrapping air at the joint between the flanges of the cover and bowl. A suitable hand pump shall be provided with the cover, either as an attachment or as an accessory.

(3) *Calibration Vessel* - The calibration vessel shall consist of a cylindrical measure having an internal volume equal to approximately 3 to 6% of the volume of the measuring bowl. A satisfactory measure may be machined from No. 16 gage brass tubing (or proper diameter to provide the volume desired) to which a brass disk 1/4 in. (6 mm) in thickness is soldered to form an end.

(4) *Syringe*

(5) *Calibration Tubes* - Auxiliary calibration tubes of appropriate diameters, provided either as an integral part of the cover assembly or separately, shall be constructed as to assist in adding and removing water from the container during the aggregate correction factor determination.

(b) *Tamping Rod* - A round, straight steel rod 5/8 in. (16 mm) in diameter and approximately 24 in. (610 mm) in length, having one end rounded to a hemispherical tip the diameter of which is 5/8 in.

(c) *Mallet* - A mallet with a rubber or rawhide head, weighing approximately 0.5 lb. (0.23 kg) for containers smaller than 0.50 cu. ft. (14 dm^3) capacity and 1 lb. (0.45 kg) or more for larger containers shall be provided.

(d) *Strike-Off Bar* - A strike-off bar consisting of a flat, straight steel bar shall be provided.

(e) *Container* - A container having a 1/2 or 1 gal. (2 or 4 litres) capacity as required, shall be provided to fill the assembled air meter with water from the top of the concrete to overflow at the petcock.

(f) *Scoop*

(g) *Scale* - A scale of sufficient capacity to determine the weights of fine and coarse aggregates required for the determination of the aggregate correction factor in Section 4.

Calibration of Apparatus

3. Rough handling will affect the calibration of pressure-type apparatus for the determination of air content. Should the accuracy of the air meter be questioned, it should be returned to the Materials Section for a calibration check.

Determination of Aggregate Correction Factor

4. Determine the aggregate correction factor on a combined sample of fine and coarse aggregate as directed in paragraphs (a) through (c).

(a) Calculate the weights of fine and coarse aggregate present in the volume, S, of the sample of fresh concrete whose air content is to be determined, as follows:

$$F_s = \frac{S}{B} \times F_b$$

$$C_s = \frac{S}{B} \times C_b$$

where:

F_s = weight of fine aggregate in concrete sample under test, in lb (kg)
S = volume of concrete sample (same as volume of measuring bowl of apparatus) in ft^3 (m^3)
B = volume of concrete produced per batch (Note 1), in ft^3 (m^3)
F_b = total weight of fine aggregate in batch, in lb (kg)
C_s = weight of coarse aggregate in concrete sample under test, in lb (kg)
C_b = total weight of coarse aggregate in batch, in lb (kg)

NOTE 1: The volume of concrete produced per batch can be determined in accordance with paragraph 6(b) of the Method of Test For Weight Per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete (DOTD Designation: TR 201).

(b) Mix representative samples of fine aggregate, of weight F_s, and coarse aggregate, of weight C_s, and place in the measuring bowl filled 1/3 full of water. Add the mixed aggregate a small amount at a time until all of the aggregate is covered with water. Add each scoopful in a manner that will entrap as little air as possible and remove accumulations of foam promptly. Tap the sides of the bowl and lightly rod the upper inch (25 mm) of the aggregate about 10 times and stir after each addition of aggregate to eliminate entrapped air.

(c) When all of the aggregate has been placed in the bowl and allowed to soak for at least 5 min., strike off all foam and excess water. Thoroughly clean the flanges of both the bowl and conical cover so that when the cover is clamped in place, a pressure-tight seal will be obtained. Attach the straight auxiliary tube, supplied with the air meter, to the threaded petcock on the underside of the cover assembly and attach the cover assembly to the measuring bowl. With both petcocks open, pump air into the air chamber until the predetermined initial pressure line is reached. Attach the curved auxiliary tube or hose to the outer end of the threaded petcock. Close the opposite petcock and remove water from the assembly to the calibration vessel by opening the main air valve between the air chamber and measuring bowl. The flow of water through the curved tube or hose can be regulated by using the petcock valve. After the calibration vessel has been filled, open the opposite petcock to drain water from the tube back into the measuring bowl. Complete the test as described in paragraph 6(d). The aggregate correction factor, G, is equal to the reading on the air content scale minus the volume of water removed from the bowl expressed as a percent of the volume of the bowl.

Sample

5. Obtain a representative sample of the concrete to be tested in accordance with DOTD Designation: S 301 of the Materials Sampling Manual.

Procedure

6. (a) *Consolidation* - Place the concrete in the measuring bowl in three layers of approximately equal volume. Consolidate each layer of concrete by 25 strokes of the tamping rod evenly distributed over the cross section. After each layer is rodded, strike the sides of the measure 10 to 15 times with the mallet to close any voids left by the tamping rod and to release any large bubbles of air that may have been trapped. Rod the bottom layer throughout its depth, taking care not to allow the rod to forcibly strike the bottom of the measure. In rodding the second and final layers, use only enough force to cause the rod to penetrate the surface of the previous layer about 1 in. (25 mm). When adding the final layer of concrete, be careful not to overfill the measure.

(b) *Strike Off* - After consolidating the concrete, strike off the excess concrete with the strike-off bar until the surface is flush with the top of the bowl. Wipe the flange of the bowl clean.

(c) *Preparation for Test* - Assemble the apparatus. Close the main air valve between the air chamber and the measuring bowl and open both petcocks. Using a syringe, inject water through one petcock until water emerges from the opposite petcock. Jar the meter gently until all air is expelled from this same petcock.

(d) *Test Procedure* - Close the air bleeder valve on the air chamber and pump air into the air chamber until the gage hand is on the initial pressure line. Allow a few seconds for the compressed air to cool to normal temperature. Stabilize the gage hand at the initial pressure line by pumping or bleeding-off air as necessary, tapping the gage lightly. Close both petcocks and open the main air valve between the air chamber and the measuring bowl. Tap the sides of the measuring bowl sharply to relieve local restraints. Lightly tap the pressure gage to stabilize the gage hand and read the percentage of air, A_1, on the dial of the pressure gage. Make sure the main air valve is closed and release the pressure by opening both petcocks before removing the cover.

Calculation

7. Calculate the air content of the concrete to the nearest 0.1% as follows:

$$A = A_1 - G$$

where:

- A = air content, percentage by volume of concrete
- A_1 = apparent air content of the sample, percentage by volume of concrete (Section 6)
- G = aggregate correction factor, percentage by volume of concrete (Section 4)

Report

8. Report the air content to the nearest 0.5 percent.

Reference

AASHTO Designation: T 152

Normal testing time is 15 minutes.